APPENDIX 5-F

East Helena Hydrologic Evaluation

Hydrometrics, Inc.
consulting scientists and engineers

M E M O R A N D U M

DATE: October 27, 2010

TO: Alicia Voss, Jim Ford, Montana Environmental Trust Group

COPY: Cindy Brooks, METG

FROM: Bob Anderson
Greg Bryce

SUBJECT: Hydrologic Evaluation in the Vicinity of the City of East Helena Public Water Supply Wells

As described in Section 3.2 of the East Helena Facility Phase II RFI Site Characterization Work Plan (Hydrometrics, 5/10), eight monitoring wells were scheduled for installation on and north of the Facility in 2010, with an optional ninth well to be completed pending further analysis. Initially, the optional well was to be completed adjacent to existing well EH-125 (north of the plant site) and beneath the silt/clay layer underlying the selenium plume in this area (Figure 1). The well was intended to provide detailed information about the silt/clay layer including its thickness and effectiveness as a barrier to vertical groundwater flow and contaminant migration. The proposed deep well was also intended to document groundwater conditions beneath the silt/clay layer, and the possible presence of a deeper aquifer north of the plant site. Besides being of general interest for the East Helena Facility site characterization, groundwater conditions beneath the silt/clay layer (and the selenium plume) north of the plant site are of interest since a number of private and public water supply wells, including the City of East Helena municipal public water supply wells, are completed at depth north of the plant site.

Due to concerns about drilling through the silt/clay layer underlying the selenium plume and potential cross contamination of aquifers, installation of the deep well was delayed pending completion of an evaluation of hydrologic conditions north of the plant site. This memorandum presents results of the hydrologic evaluation for the Lamping Field and East Helena municipal well area. Specific objectives of the evaluation include:

- Determine the hydrostratigraphy in the vicinity of Lamping Field and the East Helena public water supply (PWS) wells, including the relationship between the upper aquifer (and associated selenium plume) in Lamping Field, the underlying silt/clay layer, and the water-bearing zones for the East Helena PWS.

- Evaluate the susceptibility of the PWS wells to potential impacts from East Helena Facility-derived contaminants (arsenic and selenium), based on the hydrostratigraphy and groundwater flow patterns peripheral to the PWS wells.
- Determine if additional monitoring well(s) are needed to adequately monitor future plume migration patterns and water quality trends between the currently delineated groundwater plumes and the PWS wells.

The hydrologic evaluation relied solely on existing information, including well completion logs available from project monitoring wells and the Montana Bureau of Mines and Geology Groundwater Information Center, groundwater elevation and chemistry data collected as part of the East Helena Facility Phase II RFI, and published and private reports for the area. Although both the arsenic and selenium plumes are of interest, the evaluation focuses on the selenium plume since it extends furthest north of the two plumes, and previous analyses indicate the arsenic plume is in a steady state condition (i.e., not advancing; see Figure 2-3-13 in the Phase II Site Characterization Work Plan). Furthermore, although the susceptibility of all water supply wells to Facility-derived contaminants is of interest, the evaluation focuses on East Helena PWS well EHPWS-3 due to its proximal location north of the currently defined selenium plume. Site features and information relevant to the PWS hydrologic evaluation are shown on Figure 1. The evaluation components and conclusions are discussed below.

Hydrostratigraphic Evaluation

Hydrostratigraphy refers to the grouping of geologic units with similar hydrologic characteristics into individual interconnected groundwater-bearing units or aquifers, and low permeability confining units or aquitards. Currently defined hydrostratigraphic units in the Lamping Field area include alluvial sands, silts and gravels forming the upper aquifer, and an underlying silt/clay layer believed to act as an aquitard, or barrier to vertical groundwater flow. Of particular interest for the PWS well evaluation is the lateral extent and continuity of the silt/clay layer north of Lamping Field, and the location of the East Helena PWS well screened interval relative to the upper aquifer (and selenium plume) and the silt/clay aquitard.

In order to evaluate the hydrostratigraphy north of the plant site, geologic cross section C-C' (previously developed in the Phase I RFI) was updated and expanded northward to include East Helena PWS wells EHPSW-2 and EHPWS-3 (Figure 1). Stratigraphic information gained through completion of additional monitoring wells from 2008-2010, and from private and public water supply well logs was added to provide more detail to the cross section. Well logs utilized in the updated cross section are included in Attachment 1, and the cross section is shown on Figure 2.

Based on completion of more than 15 monitoring wells in and around the Lamping Field area (Figure 1), the upper aquifer hydrostratigraphic unit includes 60 to 80 feet of alluvial sands, silts and gravels, underlain by the silt/clay layer. The silt/clay layer appears to be continuous throughout the Lamping Field area, extending from EH-123/118 on the south to EH-139 to the northwest (Figure 1). Based on the lateral continuity and high silt/clay content of this

layer, upward or downward vertical flow through the silt/clay layer is believed to be limited, with the silt/clay layer forming an effective base to the upper aquifer in the Lamping Field area.

The hydrostratigraphy north of Lamping Field was determined largely from well completion logs for PWS well EHPWS-3, an associated test well (EHTW-3), and a nearby county monitoring well (EHMW-3). As shown on Figure 2 (and/or well logs in Attachment 1), all three of these wells encountered silt/clay at depths ranging from 116 to 136 feet below ground surface (bgs), or approximately 50 feet deeper than at EH-130 just south of Prickly Pear Creek (Figure 1). Given the relatively short distance between EH-131 and EHPWS-3 (about 1300 feet), and the consistent grade of the silt/clay layer surface projected from north Lamping Field (EH-130/EH-131) to EHPWS-3 (Figure 2; note 10:1 vertical exaggeration), the clays and siltstones noted on the logs for EHPWS-3, EHTW-3 and EHMW-3 probably correlate with the silt/clay layer identified in Lamping Field. Based on the well log for EHTW-3, the silt/clay layer is at least 90 feet thick in this area.

As shown on Figure 2, EHPWS-3 is screened from 71 to 119 feet bgs, or immediately above the silt/clay layer. None of the three well logs for this area indicate the presence of a competent aquitard above the top of the PWS well screen. This information suggests that EHPWS-3 is completed in the same hydrostratigraphic unit as the upper aquifer in Lamping Field with no physical separation from the selenium plume.

A comparison of general groundwater chemistry was conducted as a further check on the potential interconnection between the Lamping Field area upper aquifer and the groundwater system tapped by EHPWS-3. Table 1 shows June 2010 major ion concentrations for EHPWS-3 and nearby county monitoring well EHMW-3, along with several Lamping Field monitoring wells. As shown in Table 1, major ion concentrations are similar among all of the wells, with calcium and bicarbonate the predominant constituents. The slightly different water chemistry observed at well EH-130 compared to the other wells (higher concentrations of most parameters, along with higher sodium and sulfate concentrations relative to calcium and bicarbonate) is believed to be due to plant site effects, since well EH-130 is located along the east margin of the selenium plume (Figure 1). The results in Table 1 are a further indication that the Lamping Field wells and wells EHPWS-3/EHMW-3 are completed in a common groundwater system.

The hydrostratigraphic information and water chemistry results suggest that EHPWS-3 is completed in the same hydrostratigraphic unit as the selenium-bearing upper aquifer to the south. Thus, the PWS well could be susceptible to impacts from the Facility-related selenium plume, depending on groundwater flow and associated plume migration patterns in the intervening area as discussed below.

Table 1. June 2010 General Chemistry for Lamping Field Monitoring Wells and East Helena PWS Well EHPWS-3

Well	Ca	Mg	Na	K	Cl	HCO3	SO4	TDS
EHPWS-3	28	6	13	2	4	91	45	172
EHMW-3	29	7	13	3	4	100	51	196
EH-127	26	6	13	2	4	97	48	182
EH-130	36	8	25	3	7	120	78	251
EH-131	27	6	12	2	4	96	42	176
EH-136	25	6	12	2	4	94	43	180
EH-137	26	6	12	2	4	97	46	177

All concentrations in mg/L
Well locations shown on Figure 1.

Groundwater Flow Patterns

Leakage from Prickly Pear Creek and associated groundwater mounding beneath the creek has previously been recognized as a significant control on groundwater flow and plume migration patterns north of the East Helena Facility. To further investigate the effect of Prickly Pear Creek on groundwater flow, the Phase II RFI program includes monitoring of groundwater and surface water elevations along Prickly Pear Creek to quantify the extent of groundwater mounding beneath the creek. The extent of groundwater mounding has direct relevance to the PWS evaluation since significant mounding beneath the creek could prevent groundwater flow (and associated selenium plume migration) northward beneath the creek towards the PWS wells.

Figure 3 shows the groundwater potentiometric surface and selenium concentrations north of the plant site for June 2010. As previously documented, the general groundwater flow direction in the Lamping Field area is to the northwest, and the selenium plume aligns with a northwest-trending low point or trough in the groundwater table. The trough is formed in part by leakage from Prickly Pear Creek and associated groundwater mounding to the northeast, and recharge from upland areas and Wilson Ditch to the southwest. This cradling effect is responsible for the elongated appearance and northwest orientation of the selenium plume.

The extent of groundwater mounding can be determined by comparing groundwater elevations along a line perpendicular to the northwest-trending groundwater flow direction. For example, groundwater elevations decrease by about nine feet from stream stage monitoring site PPC-36 to monitoring well EH-122 (a horizontal distance of about 300 feet), and by about 10 feet from PPC-9A to EH-127 (a distance of 200 feet, Figure 3). Groundwater elevations near the center of Lamping Field are generally 12 to 15 feet lower than those along Prickly Pear Creek. Thus, the June groundwater elevations near the creek are on the order of 10 to 15 feet higher than surrounding groundwater elevations due to leakage from the creek. The similar water elevations in the creek and adjacent piezometers at both PPC-9A and PPC-36 (Figure 3) indicates that the groundwater mounding extended up to the creek bed at the time of the June 2010 measurements.

The June 2010 potentiometric data indicates that recharge from, and associated groundwater mounding beneath, Prickly Pear Creek forms an effective hydrologic barrier to groundwater flow (and plume migration) beneath the creek. Surface water leakage accounts for the low selenium concentrations observed in monitoring wells located near the creek, including the less than detect concentrations at EH-131, -136 and -137 north of the creek (Figure 3). This means that even in the absence of a confining layer between the selenium plume and the EHPWS-3 screened section, the PWS well should not be susceptible to impacts from the Lamping Field selenium plume, at least under conditions documented by the June 2010 water level data. Although the mounding effect is known to persist through the fall season, the extent of mounding during the fall and winter seasons has yet to be fully documented[1]. Water level monitoring should continue in the Prickly Pear Creek piezometers and nearby monitoring wells to better document the seasonal extent of groundwater mounding beneath the creek.

Summary and Recommendations

Based on currently available data, East Helena PWS well EHPWS-3 appears to be completed in the same hydrostratigraphic unit as the selenium-bearing upper aquifer underlying Lamping Field to the south. Although the silt/clay aquitard underlying the selenium plume appears to extend northward beyond well EHPWS-3, the top of the aquitard becomes deeper to the north and occurs below the EHPWS-3 screened interval. Similarities in general groundwater chemistry at EHPWS-3 and the selenium-bearing groundwater to the south further indicate that groundwater within these two areas is interconnected. Although there may not be a physical barrier separating the PWS well from the selenium plume, groundwater flow patterns, largely controlled by leakage from Prickly Pear Creek, appear to limit the potential for groundwater flow and selenium plume migration northward from Lamping Field towards EHPWS-3, at least on a seasonal basis. The nondetectable selenium concentrations in monitoring wells EH-131, -136 and -137 northeast of Prickly Pear Creek reflect the hydrologic barrier effect imposed by groundwater mounding beneath the creek.

Based on the fact that public water supply well EHPWS-3 is not completed in a deeper aquifer underlying the silt/clay layer, completion of a deep well through the silt/clay layer (as proposed in the Phase II work plan) does not appear necessary. Given the current plume configuration and groundwater flow patterns peripheral to Prickly Pear Creek, the existing monitoring well network appears to provide adequate coverage for monitoring the potential for future plume migration northward towards EHPWS-3, at least for the present. The lack of detectable selenium concentrations to date in monitoring wells EH-131, -136 and -137 north of Prickly Pear Creek (Figure 3) provides assurance that the selenium plume does not currently extend north of the creek (and threaten the PWS wells) in this area.

[1]As of September 30, 2010, groundwater levels at piezometers PZ-9A/9B had declined approximately four feet from the levels shown on Figure 3, while groundwater levels at EH-125 were virtually unchanged during this time.

This issue should be revisited once additional water level and water quality data are available from newly installed monitoring wells EH-138 and EH-139 (Figure 1). If information obtained from these wells warrants, additional monitoring well(s) could be drilled south of EHPWS-3 to serve as sentinel well(s) for safeguarding the PWS wells. If future information warrants, additional piezometers could also be installed adjacent to the creek near or north of PPC-37A, (Figure 3) to quantify the seasonal extent of groundwater mounding between any potential future northward extension of the selenium plume and the PWS wells.

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NORTH

SCALE
(In Feet)
0 800

LEGEND

- PUBLIC WATER SUPPLY WELL
- EAST HELENA PROJECT MONITORING WELL
- CITY/COUNTY MONITORING WELL
- PRIVATE WELL FROM PHASE II WORK PLAN WELL INVENTORY
- GEOLOGIC CROSS SECTION LINE (SEE FIGURE 2)
- 6/10 50 PPB SELENIUM PLUME CONTOUR
- 6/10 10 PPB ARSENIC PLUME CONTOUR

14 13
23 24

C'
EHPWS-2
D10

PRICKLY PEAR CREEK

EHTW-3
EHPWS-3
EHMW-3

TPPW-1
TPPW-2

23 24
26 25

EH-139
EH-138
EH-131
EH-137
EH-136
WYLIE DRIVE
D3
EH-130
EH-134
EH-129
EH-126
EH-135
EH-127
EH-125
EH-133

LAMPING FIELD

EH-121
EH-122
EH-120
EH-66
EH-67
EH-132
EH-124
EH-68
EH-69
EH-119
EH-117
EH-53
EH-62
EH-54
EH-128
EH-116
EH-113
EH-114
EH-111
EH-123
EH-112
C
EH-118
EH-64
EH-115
EH-65
EH-63
EH-106
EH-107
EH-110
EH-57A
EH-109
EH-104
EH-51
EH-52
EH-50
EH-100
EH-103
EH-61
EH-101
EH-102
EH-60
DH-54

26 25
35 36

DH-67
DH-64
DH-6
DH-10A
DH-49
DH-48
DH-50
DH-63
DH-51
DH-52
DH-24
DH-15
DH-65
DH-1
DH-16
DH-56
DH-66

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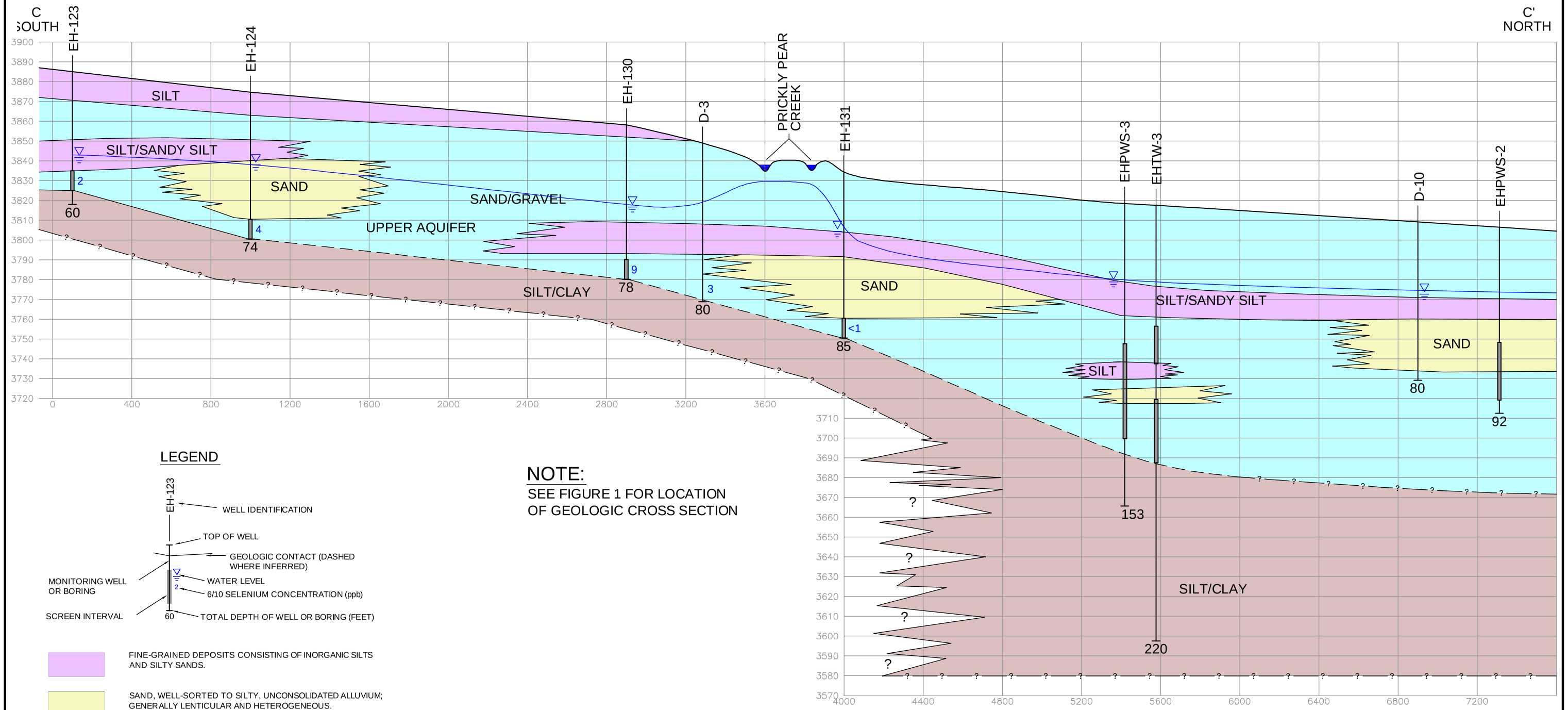
HYDROLOGIC EVALUATION IN VICINITY OF THE EAST HELENA PUBLIC WATER SUPPLY WELLS

WELL LOCATIONS AND SITE FEATURES FOR PWS HYDROLOGIC EVALUATION

FIGURE
1



LEGEND

FINE-GRAINED DEPOSITS CONSISTING OF INORGANIC SILTS AND SILTY SANDS.

SAND, WELL-SORTED TO SILTY, UNCONSOLIDATED ALLUVIUM; GENERALLY LENTICULAR AND HETEROGENEOUS.

ALLUVIAL SAND AND GRAVELS, WITH VARIABLE AMOUNTS OF SILT OR CLAY.

FINE-GRAINED DEPOSITS CONSISTING OF VARYING PROPORTIONS OF SILT AND CLAY. RESEMBLES WEATHERED VOLCANIC ASH IN PLACES. INTERPRETED TO BE TERTIARY SEDIMENTS.

NOTE:

SEE FIGURE 1 FOR LOCATION OF GEOLOGIC CROSS SECTION

SECTION C-C'

SCALE: (H) 1"=500' (V) 1"=50'

HYDROLOGIC EVALUATION IN VICINITY OF THE EAST HELENA PUBLIC WATER SUPPLY WELLS	**GEOLOGIC CROSS SECTION NORTH OF FACILITY**	FIGURE **2**

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NORTH

SCALE
(In Feet)
0 400

LEGEND

- EH-119 3840.84 <1 — MONITORING WELL WITH 6/10 GROUNDWATER ELEVATION 6/10 SELENIUM CONCENTRATION
- PIEZOMETER
- STREAM STAGE SITE
- PUBLIC WATER SUPPLY WELL
- CITY/COUNTY MONITORING WELL
- 3820 — GROUNDWATER POTENTIOMETRIC CONTOUR - 5 FOOT INTERVAL (DASHED WHERE INFERRED)
- GENERALIZED GROUNDWATER FLOW DIRECTION
- 6/10 50 PPB SELENIUM PLUME CONTOUR

EHMW-3
3785.61
<1

EHPWS-3

EH-138
NA
NA

EH-131
3803.60
<1

EH-137
3805.94
<1

PPC-37A
3830.50

EH-136
3813.28
<1

3830

EH-130
3816.26
9

EH-129
3818.86
2

EH-134
3819.28
<1

EH-126
3818.25
44

3820

EH-135
3828.06
<1

PZ-9A/B
3844.25 /
3844.13

PPC-9A
3847.08

EH-127
3837.35
<1

3825

3830

EH-125
3831.47
84

EH-133
3836.86
<1

3835

PZ-36A/B/C
3856.36 /
3856.10/
3855.19

PPC-36
3857.36

EH-121
3845.34
NA

EH-122
3848.52
<1

EH-66
3845.64
NA

EH-67
3849.30
<1

3855

EH-120
3837.94
150

EH-132
3846.67
<1

3840

EH-124
3838.56
4

3845

3850

EH-119
3840.84
72

EH-117
3843.49
139

EH-128
3854.74
<1

EH-116
3844.34
175

EH-113
3844.42
100

EH-53
3845.84
43

EH-62
3852.74
4

EH-123
3844.39
2

EH-118
3843.95
8

EH-114
3845.61
229

EH-111
3847.12
120

EH-112
3848.53
63

EH-206
3854.73
NA

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HYDROLOGIC EVALUATION IN VICINITY OF THE EAST HELENA PUBLIC WATER SUPPLY WELLS	**JUNE 2010 POTENTIOMETRIC MAP AND SELENIUM CONCENTRATIONS**	FIGURE **3**